FERMILAB-UPC-156

Fermilab

A-SECTOR KAUTZKY VALVE TESTS IN SITU

C. T. Murphy

February 10, 1982

All Kautzky relief valves in A-sector were tested as installed in the tunnel to verify that they would open and get cold (i.e., cold gas flowed through them) when the control pressure was bled down to ≤2 psig. The procedure followed is given in Appendix A. Data were also taken on the bleed-down time for the Kautzky control pressure and the extension of the 8" diameter bellows in the header resulting from thermal contraction of the 8" pipe during the cold gas flow.

The results of the test are that all 171 valves did open. All except one reseated properly after being cold for two to three minutes. The procedure worked well as written, except that we extended the valve open time (cooldown time) from the proposed one minute to three minutes in order to get definite frosting of the valves at the ends of the strings farthest from the refrigerator building. The procedure takes about 20 minutes per house (after everyone is in place and instructed), or 45 minutes if one waits for firm evidence that all valves are warming. Recommended tools are clipboard, flashlight, 9/16" wrench, safety glasses, propane torch, and SNOOP bottle (in case of necessary repairs - see below).

During the three minute valve open time, the control pressure lines were pumped out by a small forepump at the control manifold in the MR service building in an effort to remove any remaining air from the system. We doubt that the effort did any good. The vacuum gauge never came unpegged (pressure remained above 1/4 atm.). Whatever air was in the system was probably cryopumped into the cold bellows chamber of the Kautzky valve at the bottom (gravitationally) of the system. In the future, pumpouts must be scheduled when the magnet string is warm and be allowed to pump for several hours.

Some general observations and comments on the rationale of the procedure are worth noting for future reference. It is important that the single-phase system be full of either subcooled liquid or 2Ø, and not be all gas. In the case of an all gas system, the first handful of valves which open get all the flow and the rest never get cool (a result from two months ago). But we could not see any difference in the amount of valve frosting between an all liquid string and the one half-house which had only a 2Ø mixture in the 1Ø system (A-1 downstream, according to Andrews).

We believe, but cannot prove conclusively, that it is important to open the valves by reducing the control pressure to zero, thereby opening the valves with the spring built into the bellows of the Kautzky valve, rather than by trying to force the valves open by

overpressuring the 1Ø system. In our method, all valves will open after about 25 seconds and each will receive some flow resulting from the boil-off even in the absence of any driving pressure in the 1Ø system. In the rejected procedure (overpressuring the 1Ø system), it was feared that the first few valves to open would regulate the 1Ø pressure back down such that the rest would never open.

In our tunnel inspections immediately following valve cooldown, the following qualitative properties of the amount of frosting were observed in all three houses. The heaviest frosting was on the 2Ø and 1Ø valves on the spool piece at the feedcan. Proceeding away from the feedcan, the 1Ø valves on spool pieces were progressively less frosted, and the last one at each end of the string was not frosted (but cold). The 2Ø valves, on the other hand, were more or less identically frosted throughout the house. Dipole 1Ø valves were all frosted, but slightly more heavily nearer the feed can. Of the LN2 relief valves, only the four or five nearest to the feedcan were frosted; the three or four most distant were merely cold.

Lastly, a very rapid initial walk-through is highly recommended in order to get a fast snapshot in the mind before time both changes the state of frost and blurs the mind. Valves that are behaving differently from their nearest neighbors (remembering to compare dipoles to dipoles and spools to spools) stick out more readily. Two teams proceeding in opposite directions from the feedcan is a very useful luxury.

No difficulty in refrigerator recovery from this insult to the system was reported to me. This is a compliment to the refrigerator controls system and the operators.

The bleed-down time of the Kautzky control gas system is 20 seconds, the time necessary to drop from 30 psig to 2 psig (at which pressure the valves are half open). See Fig. 1.

The 8" expansion joint bellows in the 8" header were extended on the average by .37" more just after the valve cooldown (about two minutes after end of cooldown) than they were about 30 minutes later (warm-up nearly complete).

The remainder of this note gives detailed results house-by-house. Attached as appendices for possible future reference are the tunnel inspection check lists and time plots of several refrigerator parameters during the valve cooldown period.

A-3 Details

The leak rate of the independent upstream and downstream control pressure systems was measured by valving off the supply bottles. The leak rates were 0.1 and 0.3 psi per six minutes for the upstream and downstream systems, respectively.

During the bleed-down of the control pressure, the pressure was recorded at five second intervals, taking care to close the vent for about a second to measure an equilibrium pressure. The data are shown on Fig. 1. The one second valve-closed times have been subtracted from the time scale.

The tunnel was reached about five minutes after the end of cool-down. The length of three 8" bellows were immediately measured and then remeasured about 45 minutes later after all frost had vanished from the valves. The extensions when cold (cold length minus warm length) were:

A35-2 - .375"
A36-5 - .500"
A37-5 - .375"

All valves were frosted or cold except two. The A29-5 dipole valve felt as if it was at room temperature, whereas its neighbors were frosted. We areconfident that there was nearly no flow through this valve. We therefore removed the copper control pressure line at the actuator for about two seconds. The valve "gurgled," liquid air rained from the flex hose, and the valve and flex hose proceeded to frost up. While the copper line was disconnected, it did hiss, proving that there was not a large constriction in the copper line which prevented the valve from being bled down during the previous opening of all valves. We have no good explanation of its previous failure to get cold. We can invent a possible explanation. Perhaps this valve opened later than its neighbors because of a smaller value of (spring constant) times (stroke); by the time it opened, the pressure difference between the 1Ø and the header at this far end of the string had been reduced to zero by the venting through the other valves, and the 10 watt heat leak was insufficient to lift the check valve in the magnet.

A valve on the 1Ø outlet of the A32 spool piece felt only cool, not cold. It worked fine when its copper control pressure tube was briefly removed. Later experience taught us that its "cool" status (instead of cold) is typical for the 1Ø spool reliefs farthest from the feedcan. We did not inspect this valve until a full 15 minutes from the end of the cooldown, during which considerable warming occurred.

A-2 Details

In the A-2 test, the cooldown time was extended from two to three minutes, and the time gap between end of cooldown and inspection of the last valve was shortened from 15 minutes to seven minutes, in hopes of eliminating any false failures such as the two reported above. The performance of the A-2 valves was perfect.

More bellows expansions (cold minus warm) were measured:

A-21 - 0.250"
A-23 - 0.312"
A-25u - 0.25"
A-25d - 0.50"
A-27 - 0.437"
A-29 - 0.312"

A-1 Details

The A-1 test was performed with no further changes in the procedure. We were advised by Dick Andrews (from the MRC Doubler Console) that the downstream A-1 1Ø system was not liquid but 2Ø; however, Misek detected no difference in the amount of frosting from what he had observed half an hour earlier in downstream A-2.

All valves frosted or felt cold. The A-14 spool piece 1Ø valve was detected as leaking during the return walk following the fast inspection. The flex hose was "smoking" more than neighboring spool piece hoses, and on closer examination, the 1Ø valve was more frosted than neighboring spool piece 1Ø valves. Upon listening to the valve, we realized that it was pulsing - venting about every four seconds for about two seconds. Later speculation attributes this pulsing to vaporization of liquid trapped between the spool piece check valve and the Kautzky valve. In an attempt to make the valve reseat properly, we first raised the control pressure to 45 psig. The audible pulsing continued. We then had Gannon "pop" the valve open twice, using the solenoid control, in hopes of blowing out any trapped debris or giving it another chance to seat differently. The pulsing then ceased, although the frost became more heavy because of cold flow during the "popping." Half an hour later, the frost line was observed to be shrinking. The remaining frost was removed with a propane torch, in order to prove that the valve would remain warm.

Conclusions

These tests were suggested by people who were not personally aware of the thoroughness of the bench testing of these valves before they are put in the tunnel. I agreed to the tests because of the fact that the valves have been handled in the tunnel in a rather dirty manner and might have been fouled. Since all 171 valves did open, I conclude that this test is unnecessary in the future. The test will occur automatically at the first quench.

On the otherhand, we have learned how to test these valves in situ, and will be able to repeat the test in the future if periodic tests of the valves are deemed necessary. I would recommend an annual test of the valves such as we have done, if only to prove that they have not become glued shut for some reason after being under pressure for a year.

Acknowledgements

I thank Bill Fowler for his help in writing the procedure. I thank Joel Misek, Don Mizicko, Karl Koepke, and Charlie Bonham for their participation in these tests, and the cryogenic operators for their cooperation.

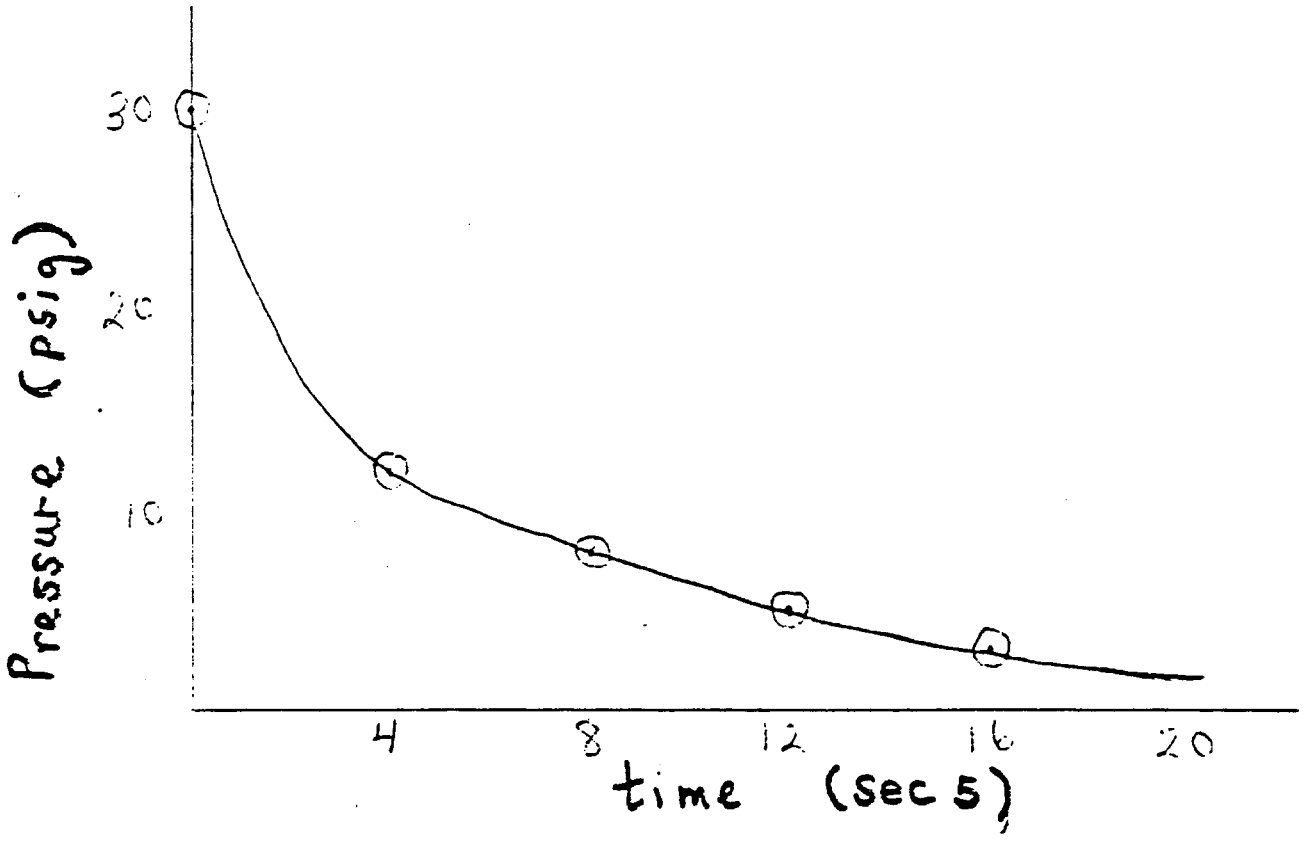


Figure 1. Pressure as a function of time in the Kautzky control pressure system as it is bled down from the MR Service Building.

Fermilab

Revised February 9, 1982
February 5, 1982
CTM

PROCEDURE FOR VERIFYING THAT ALL KAUTZKY VALVES WILL OPEN IN A1, A2, A3

PURPOSE

To verify that all 1Ø and 2Ø helium and liquid nitrogen relief valves open at Kautzky control pressure ≤2 psig.

SKETCH OF METHOD

Reduce Kautzky control pressure to ≤2 psig with magnet string full of liquid helium. After control pressure is ≤1 psig for one minute the Kautzky control pressure will be restored to its previous valve. (During the test the three JT's, wet engine, and bypass will be left in automatic.) After repressurizing the Kautzky control pressure to 30 psig, an access to the tunnel for inspection within ten minutes will be made (all Kautzky valves should be cold, but in state of warming).

DETAIL OF STEPS

1. Two people at MR Service Building A3 phone MCR Doubler console for permission to proceed. Verify that string is full of liquid. Maintain open phone line to MCR until beginning step 8. Verify that suction pressure is ≅2 psig.
2. CAUTION: Refrigerator operator places transfer line feed valve A3EVLH in manual and makes certain that this valve is closed.
3. Close valves A3MVUps K Shutoff and A3MV Dns K Shutoff. (See Fig. 1.)
4. Open valves A3MV Ups K Bleed and A3MV Dns K Bleed. (System should take ~40 seconds to bleed down to -1 psig. Kautzky valves will be half open at 2 psig.)
5. After both pressure gauges read ≤2 psig, or after there is no audible indication of further venting, wait three (3) minutes. (Boil-off gas from magnets should now be flowing through the Kautzky valves cooling them.)
6. After waiting the above three minutes, close A3MV Ups K Bleed and A3MV Dns K Bleed, then open A3MV Ups K Shutoff and A3MV Dns K Shutoff.

7. After control pressure system is fully charged to 30 psig (wait at least two minutes), obtain MCR permission to access tunnel for inspection.
8. MR tunnel inspection. (All valve bodies should be cold but in state of warm-up.) Using enclosed check lists, verify whether or not each valve is
   a. cold
   b. leaking cold gas at any flange
   c. appears to be still leaking (i.e., frost line growing bigger.)

APPENDIX B

DETAILED INSPECTION CHECK LISTS

Kantsky valve inspection
following deliberate opening of valves

date ______
initials ______
valves open for ______
end cool down at: ______
begin inspection at: ______
end inspection at: ______

lve. loc. #	cold?	leaks at O-ring?	is it warming?	comment

Kentucky valve inspection following deliberate opening of valves

date 2/6/86
initials [illegible]
valves open for 180 sec
end cool down at: 4:23
begin inspection at: 4:25
end inspection at: 4:28

valve loc #	cold?	leaks at O-ring?	is it warming?	comment
A12 - LN2	✓	no	✓	
2Φ	✓	no	✓	
1Φ	✓		✓	
A12 - 2	✓			
3	✓			
4	✓			
5	✓			
A13 - LN2	✓			
2Φ	✓			
1Φ	✓			
A13 - 2	✓			
3	✓			
4	✓			
5	✓			
A14 - LN2	✓			
2Φ	✓		✓	had to raise pressure to 45 psig and "popped" it twice. The leak was cyclical with about 3 sec period – could hear it pulsing
1Φ	✓		(No)	
A14 - 2	✓		✓	
3	✓		✓	
4	✓			
5	✓			
A15 - LN2	✓			
2Φ	✓			
1Φ	✓			

3510 Kentucky valve inspection following deliberate opening of valves

date 2/8/82
initials CJM, KK
valves open for 180 sec
cool down at: 3:50 pm
begin inspection at: 3:56 pm
end inspection at: 3:59 pm

valve loc. #	cold?	leaks at O-ring?	is it warming?	comment
A21-DTA	✓	no		
A21-2	✓	✓		
3	✓			
4	✓			
5	✓			
A22-LN2	✓			
2Φ	✓			
1Φ	✓			
A22-2	✓			
3	✓			
4	✓	✓		
5	✓			
A23-LN2	✓			
2Φ	✓			
1Φ	✓			
A23-2	✓			
3	✓			
4	✓			
5	✓			
A24-LN2	✓			
2Φ	✓			
1Φ	✓			
A24-2	✓			
3	✓			
4	✓			
5	✓	✓		
A25-LN2	✓	no		
2Φ	✓	no		
1Φ	✓	no		

Kautz hy valve inspection

Date 2/8/82

Initials CGM

After deliberate opening of valves

valves open for ≈ 120 cc

time of end of cooldown of valves 11:15

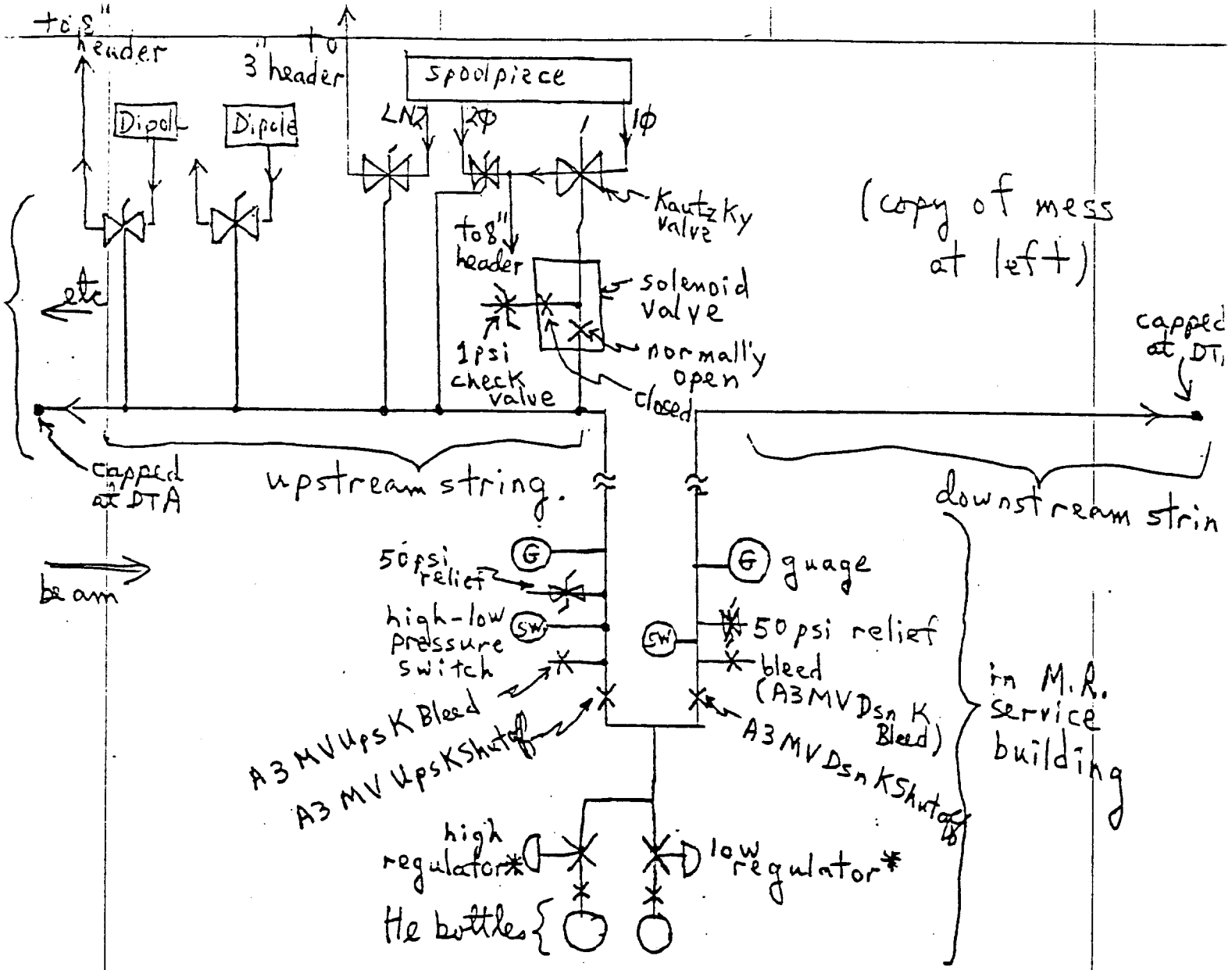
time: begin inspect 11:25

time: end inspect 11:30

valve #	cold?	leaks at O-ring?	is it warming?
A29 DTA	cool	no	
A29-2		no	
-3			
-4			
-5	NO		retested by removing copper tube. Is OK
A32-LN2	cool		
2φ			
1φ	OK?		retested by removing copper tube. Is OK
A32-2			
3			
4			
5			
A33-LN2	cool		
2φ			
1φ			
A33-2			
3			
4			
5			
A34-LN2	barely		
2φ			
1φ			
A34-2			
3			
4			
5			
A35-LN2			
2φ			
1φ			

"warming" could not judged until ≈ 11:45

cy



Doubler Relief Valve Control Pressure System For 1/4 Sector

* low regulator set 3 psi below low-pressure trip switch
  high " " " " above high- " " "

Revised 2/5/82 ctm
As-built, A1, 2, 3

Fig. 1

orig.: 1/15/81
CTM

APPENDIX C

TIME PLOTS OF REFRIGERATOR PARAMETERS

Kentucky valve inspection following deliberate opening of valves

date [illegible]
initials [illegible]
valves open for 180 sec
end cool down at: 4^{25}
begin inspection at: 4^{27}
end inspection at: 4^{30}

alve loc #	cold?	leaks at O-ring?	is it warming?	comment
A15-2	✓	NO		
3	✓	NO		
4	✓	↓		
5	✓	↓		
A16-LN2	✓	↓		
2¢	✓	↓		
1¢	✓	↓		
A16-2	✓	↓		
3	✓	↓		
4	✓	↓		
5	✓	↓		
A17-LN2	✓	↓		
2¢	✓	↓		
1¢	✓	↓		
A17-4	✓	↓		
5	✓	↓		
A18-LN2	✓	↓		
2¢	✓	light		
1¢	✓	light		
A18-2	✓	↓		
3	✓	↓		
4	✓	↓		
5	✓	↓		
A19-LN2	cool	↓		
2¢	✓	light		
1¢	✓	light		
A19-2	✓	↓		
3	✓	↓		
4	✓	↓		
5	✓	↓		
A21-LN2	cool	↓		
2¢	✓	↓		
1¢	✓	↓		

Kentucky valve inspection following deliberate opening of valves

date 2/8/82
initials [illegible]
valves open for 180
sub cool down at: 3:55
begin inspection at: 3:22
end inspection at: 4:05

valve loc. #	cold?	leaks at O-ring?	is it warming?	comment
A25 - 2	✓	no		
3	✓	no		
4	✓			
5	✓			
A26 - LN2	✓			
2Φ	✓			
1Φ	✓			
A26 - 2	✓			
3	✓			
4	✓			
5	✓			
A27 - LN2	✓			
2Φ	✓			
1Φ	✓			
A27 - 2	✓			
3	✓			
4	✓			
5	✓			
A28 - LN2	cold			
2Φ	✓			
1Φ	✓			
A28 - 2	✓			
3	✓			
4	✓			
5	✓			
A29 - LN2	cold			
2Φ	✓			
1Φ	✓			
A11 6 1/4 (6 13/16)		✓		
A23 6 15/16 (5 3/4 / 10)		A-25 D	7/8	A-25 up 6 7/8 — A-27 7" (2 3/8 / 12 1/4) — A-29 7 3/8"

date 2/8/82

Initials CGM

valves open for ~120 secs

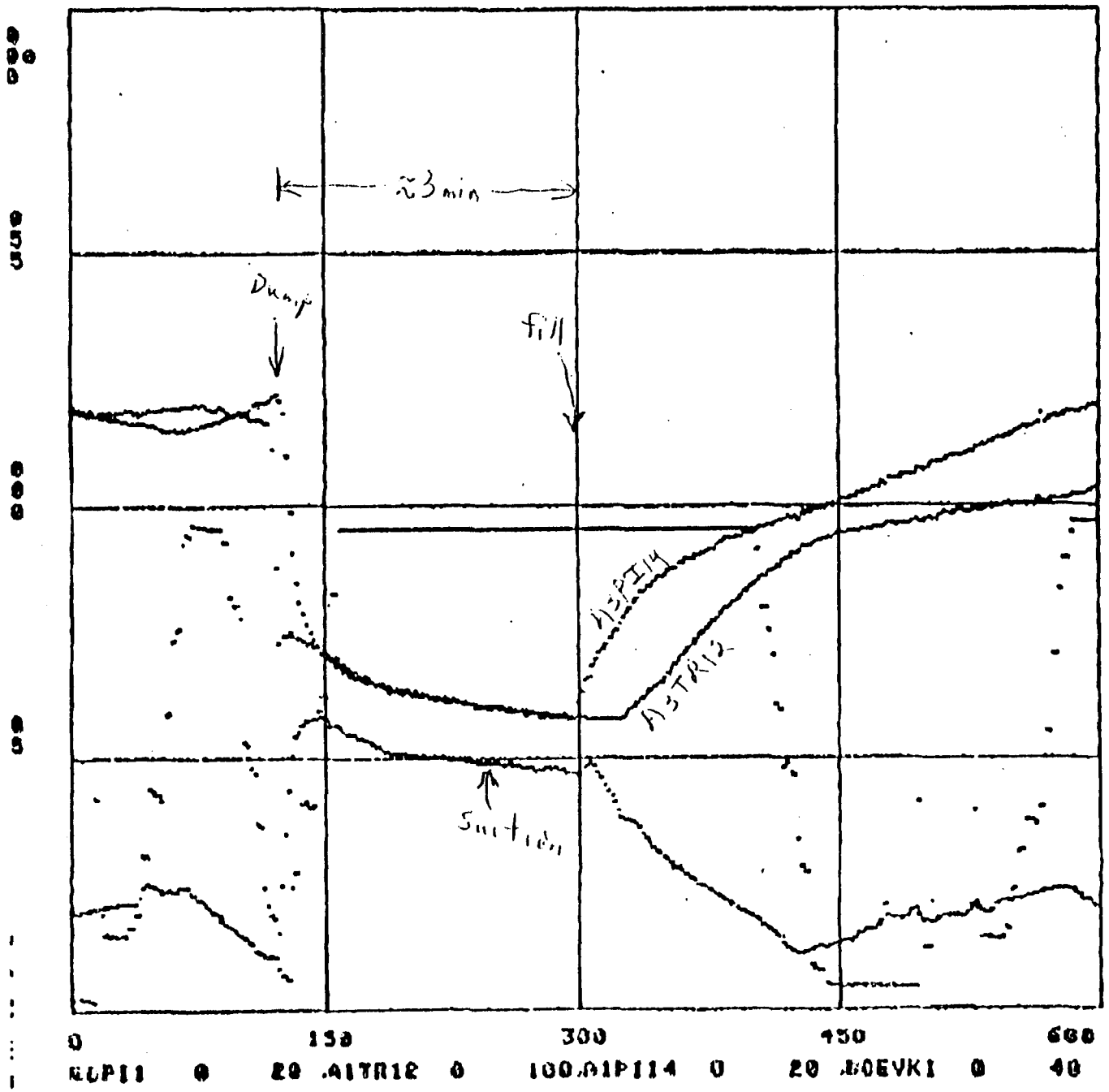
time start of valve cooldown 11:15

time begin inspect 11:20

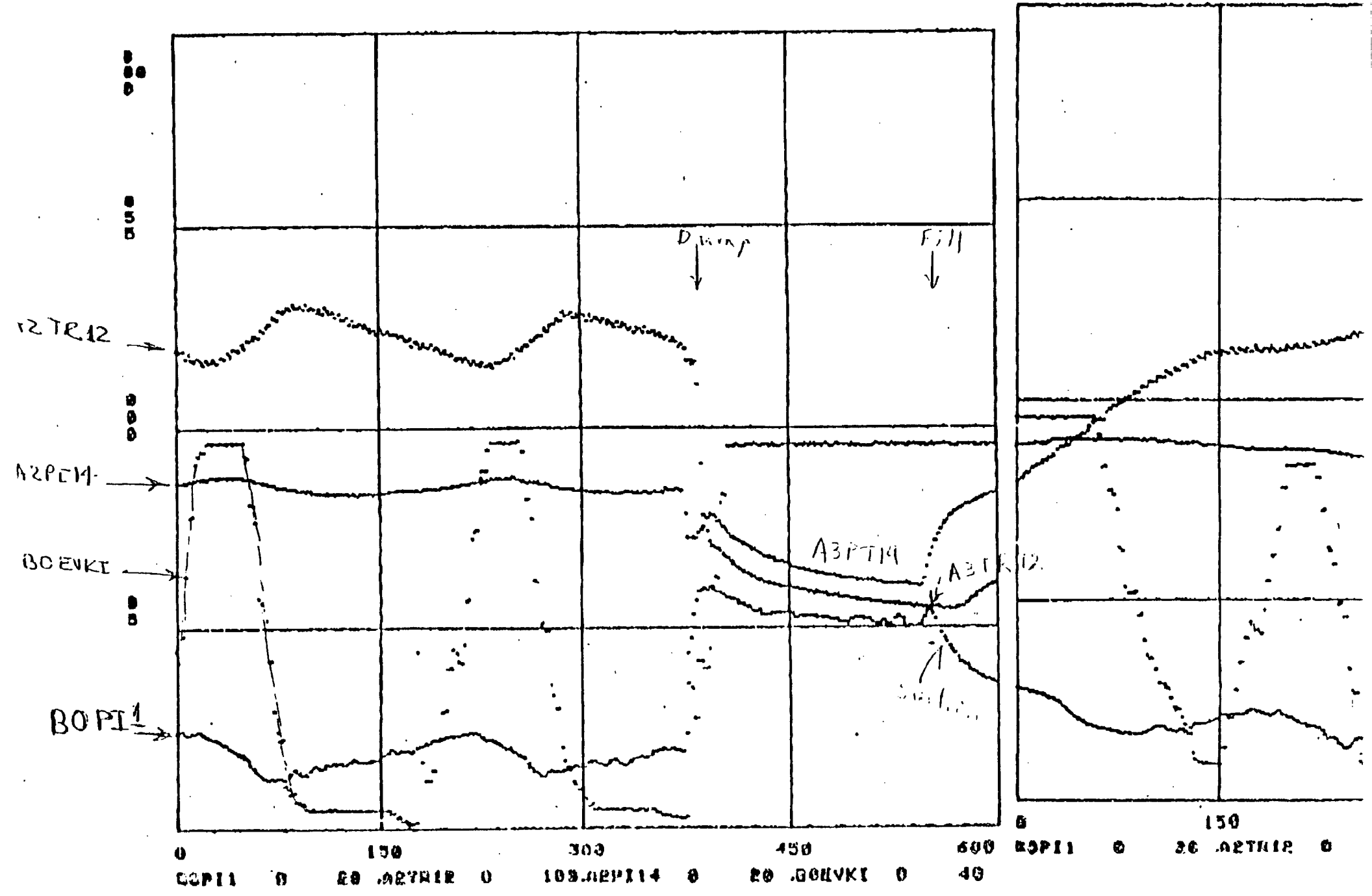
time end inspect 11:25

	cold?	leaks at O ring?	is it warming?
A35-2		no	
3		no	
4		no	
5		no	
A36-LN2		no	
2φ		no	
1φ		no	
A36-2		no	
3			
4			
5			
A37-LN2			
2φ			
LN2			
A37-2			
3			
4			
5			
A38-LN2	barely		
2φ			
1φ			
A38-2			
3			
4			
5			
A39-LN2	barely		
2φ			
1φ			

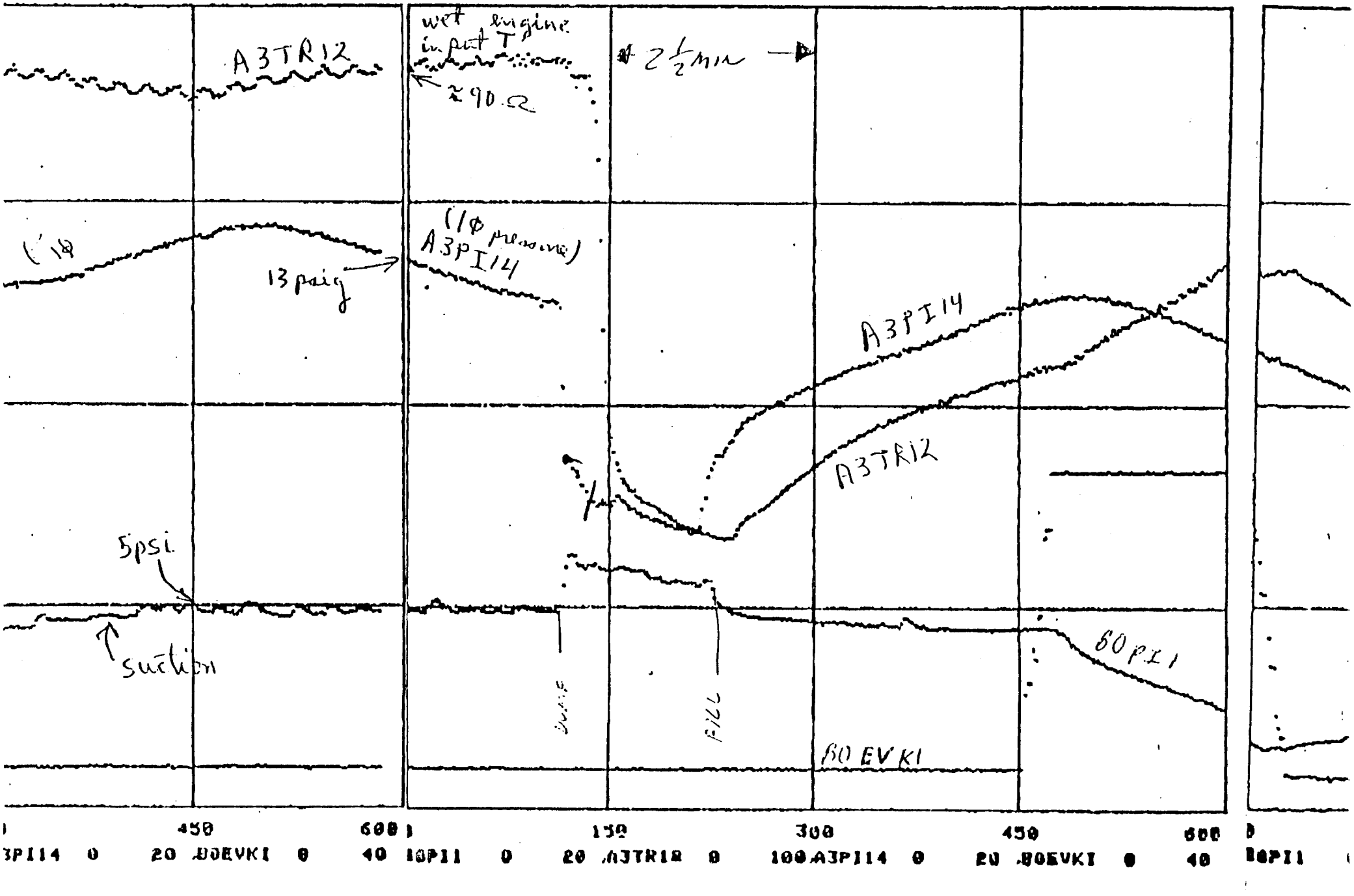
A-1



A2


D
F
A2TR12
A2PEM
BOENKI
A3PEM
A3TR12
BOPI1
0
150
300
450
600
BOPI1 0 80 A2TR12 0 100 A2PI14 0 80 BOENKI 0 40
0
150
BOPI1 0 80 A2TR12 0

A3


A3TR12
wet engine inlet T
≈90 Q
2½ min
(10
13 psig
(10 pressure)
A3PI14
A3PI14
A3TR12
5psi
suction
BOEVKI
BOPI1
450
600
150
300
450
600
3PI14 0 20 BOEVKI 0 40
10PI1 0 20 A3TR12 0 100 A3PI14 0 20 BOEVKI 0 40
BOPI1